9. Riparian Zone Module

T.B. Miley and P.W. Eslinger

The riparian zone is the vegetated corridor of land adjacent to the river where there is significant interaction between groundwater and river water. It is an area of transition between aquatic and upland ecosystems. The purpose of the Riparian Zone Module is to calculate the concentrations in riparian zone seep water and the associated wet soil.

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Results

Riparian zone results from the SAC initial assessment are available for 25 realizations of 10 contaminants. For the ecological impact model, concentrations in seep water and wet soil are calculated at 337 locations for 221 different years in the range 1990 and 3050. For the human impact model, concentrations in seep water and wet soil are calculated at 23 locations for 231 different years in the range 1980 and 3050. About 40 million concentration data values were prepared by the Riparian Zone Module.

Due to the large number of data, only summary results are provided in this section. Additional results are provided in the history matching subsection. Figure 9.1 shows the modeled seep water concentrations over time for all realizations of chromium at the 100 K Area. These concentration data were developed for use in the ecological impact model. The first year data were saved for this domain was 1990. The groundwater model results suggest that the peak chromium concentrations in seep water would have occurred in the late 1960s or early 1970s.

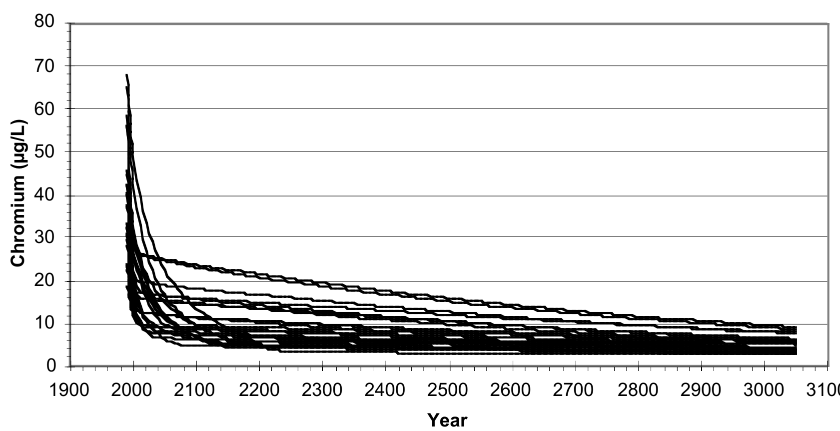

Figure 9.1. *Modeled seep water concentrations over time for all realizations of chromium at the 100 K Area.*

The modeled seep water concentrations by Columbia River mile in the year 2000 for all realizations of chromium are shown in Figure 9.2. The upper end of the domain is the Vernita bridge while the lower end

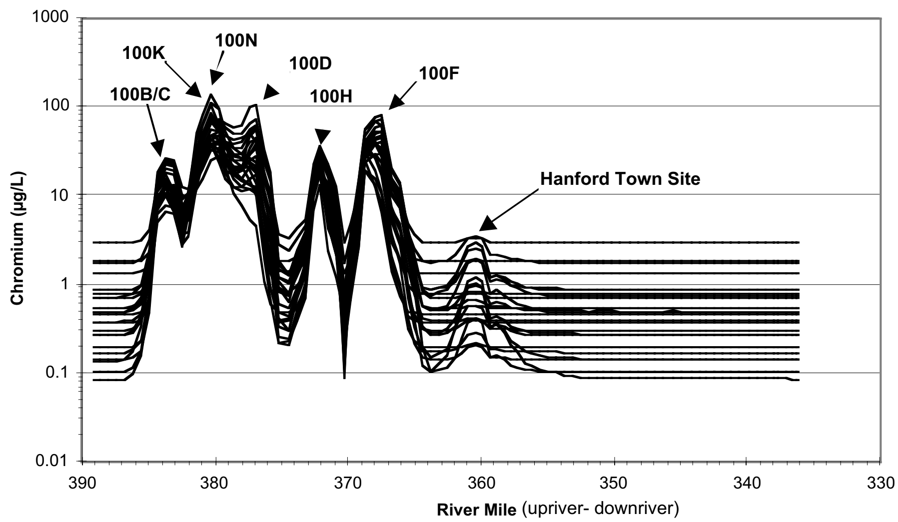

Figure 9.2. *Modeled seep water concentrations by Columbia River mile in the year 2000 for all realizations of chromium.*

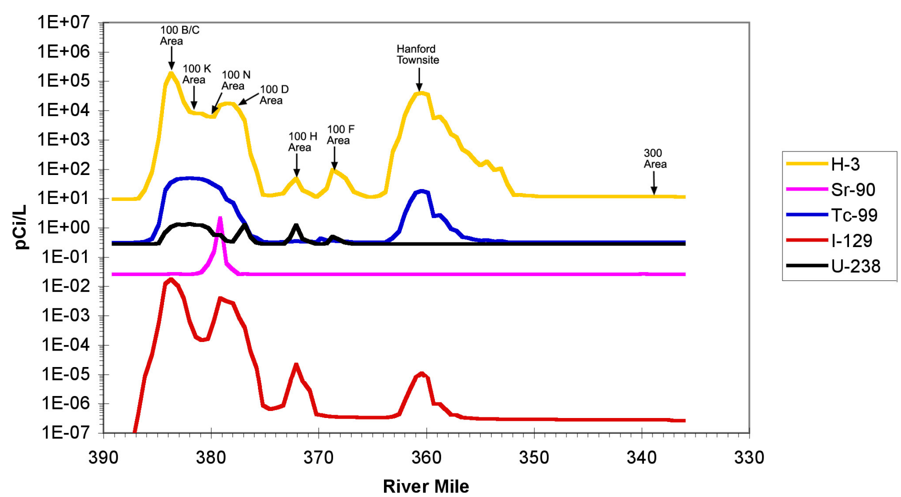

Figure 9.3. *Modeled seep water concentrations by Columbia River mile in the year 2000 for all radioactive contaminants.*

of the domain is where the Yakima River empties into the Columbia River. The influence of past discharges of cooling water to the ground in each of the reactor areas can be seen in Figure 9.2. The concentrations near the Hanford town site are due to a plume migrating from the 200 East Area.

The modeled seep water concentrations by Columbia River mile in the year 2000 for realization 1 of all radioactive contaminants are shown in Figure 9.3. Cesium-137 is not shown in the figure because the groundwater model did not release any cesium-137 to the river. The flat portions of the curves are those areas where the groundwater model did not deliver the contaminant to the river; thus, the concentrations are solely due to modeled background concentrations of the contaminant in river water. As discussed in Chapter 3, the inventory of iodine-129 in the 200 Areas for the PUREX and REDOX Plants is too low. Inclusion of this inventory has the potential to raise the seep water concentration of iodine-129, especially near the Hanford town site.

Figure 9.4 shows the modeled groundwater, seep water, and surface water concentrations by realization for chromium in the year 2000 at the 100 K Area. The figure illustrates that seep water concentrations lie between the concentrations in groundwater and river surface water. The background concentrations for river water are low compared to the groundwater concentrations, and the releases from the 100 B/C Area upstream from the 100 K Area are diluted in the river; thus, this figure illustrates the effect of concentrations in groundwater on the seep water concentrations.

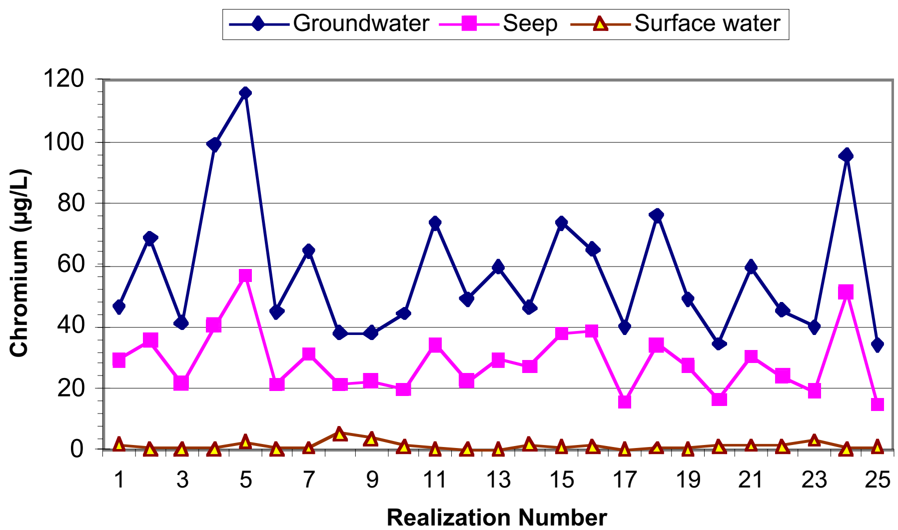

Figure 9.4. *Modeled groundwater, seep water, and surface water concentrations by realization for chromium in the year 2000 at the 100 K Area.*

Conceptual Model

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (Poston et al. 2001). Groundwater provides a means for transporting Hanford-associated contaminants that have leached into groundwater to the Columbia River. Contaminated groundwater discharges into the Columbia River through surface and subsurface seeps.

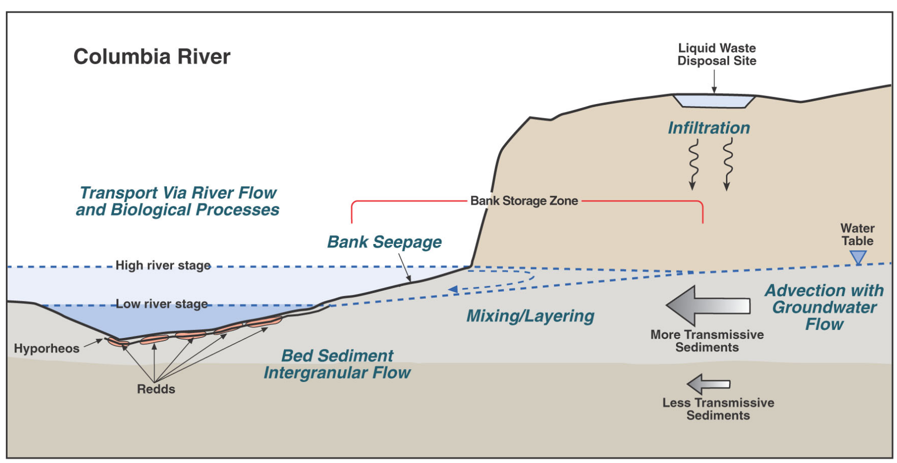

Figure 9.5. *Conceptual model for the Riparian Zone Module.*

The water levels in the Columbia River in the vicinity of Hanford vary seasonally due to precipitation and runoff and daily due to the operation of the Priest Rapids Dam upstream of the Hanford Site. Water flows into the river bank as the river stage rises and flows from the bank into the river when the river stage declines. Water discharged from the seeps following a river stage decline consists of a mix of river water and groundwater. The percentage of groundwater in the seep water increases over time following a drop in river stage. Figure 9.5 shows a diagram of the riparian zone conceptual model.

Implementation Model

The Riparian Zone Module relies on input from the Groundwater and River Modules.

The Riparian Zone Module relies on input from the Groundwater and River Modules. The input includes the spatial and temporal distribution of contaminant concentrations in the groundwater and surface water. These input data are annual, time-averaged, concentrations, so seasonal and daily changes in river stage are not reflected in the seep and riverbank soil concentrations calculated by Riparian Zone Module.

Figure 9.6 shows the location of the Riparian Zone Module in the SAC sequence of calculations. The Riparian Zone Module is the final environmental module, and it runs only after completion of the Groundwater and River Modules. Following the completion of the run(s) for the implementation model, the concentration dataset for the Risk/Impact Module is complete.

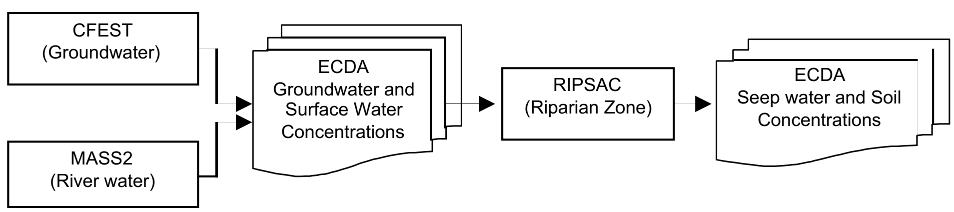

Figure 9.6. *Implementation model for the Riparian Zone Module.*

Numerical Model

The numerical RIPSAC model was written for the SAC initial assessment to model the groundwater/river water interface. Seep water and riparian soil calculations are calculated only for user-specified locations and times. The model uses a stochastic mixing fraction to calculate the seep water concentration as a linear combination of groundwater and river water. The riparian soil concentration is the product of the calculated seep concentration and a stochastic K_d value.

History Matching

Measured seep concentrations from 1990 to 1995 were used in the Columbia River Comprehensive Impact Assessment (CRCIA) (DOE/RL 1998a) to provide the input environmental concentrations for human health and ecological impacts modeling. In a history matching exercise, these CRCIA data were compared to the 1995 Riparian Zone Module seep concentrations for selected contaminants and locations.

The results from the Riparian Zone Module are annual (time-averaged) seep and wet soil concentrations. The data from field observations are point-in-time measurements of contaminant concentrations and are not expected to exactly match the modeled values. In 1988, the Surface Environmental Surveillance Project began to monitor selected riverbank springs (Poston et al. 2001). The Surface Environmental Surveillance Project defines a spring as a discharge zone located above the water level of the river. Springs are most readily identified immediately following a decline in river stage. The Surface Environmental Surveillance Project samples springs annually in the late summer and early fall, when river flows are low. Given the predominance of the Surface Environmental Surveillance Project data in the sampled data, the model generally is expected to predict lower concentrations than the sampled data. However, the concentrations in sampled data also can vary substantially depending on the time of sampling versus the time of change in river level that exposes the seep (Peterson and Connelly 2001).

The history matching results indicate that as a stand-alone module, the Riparian Zone Module can provide realistic concentration estimates.

A comparison of the modeled seep concentration of chromium at 100 K Area to measured seep data for 1995 is provided in Figure 9.7. The model performs well in this example. The sampled data were collected from 1991 through 1995, but were pooled for this comparison. A similar comparison was performed at the 100 D Area. The model predictions at 100 D are a factor of 100 times or more lower than the sampled values. The most likely reason for the discrepancy is a low inventory in the 100 D trench in the model.

The data in Figure 9.7 show modeled performance for the situation where there is a large contaminant source relatively close to the seep. Figure 9.8 shows a comparison of the modeled seep concentrations of strontium-90 at the 300 Area to the CRCIA seep data for 1995. In this case, the contaminant source is quite small but still located relatively close to the seep. The model also provides credible concentrations.

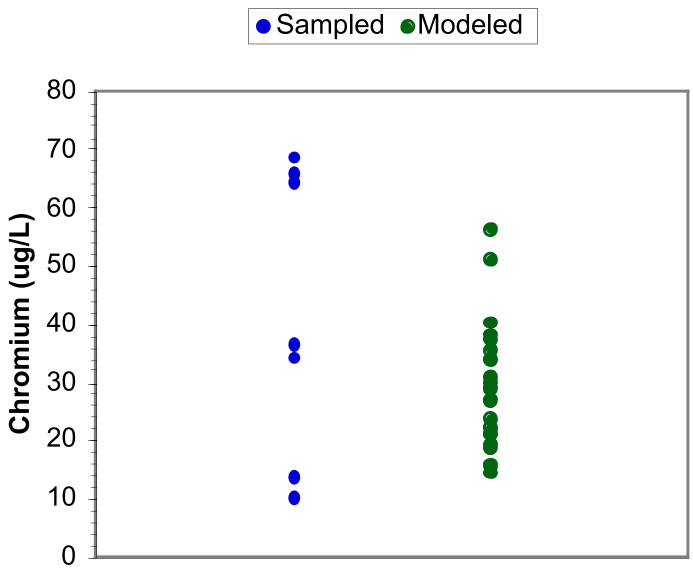

Figure 9.7. *Modeled and sampled concentrations of chromium in seep water at the 100 K Area for 1995.*

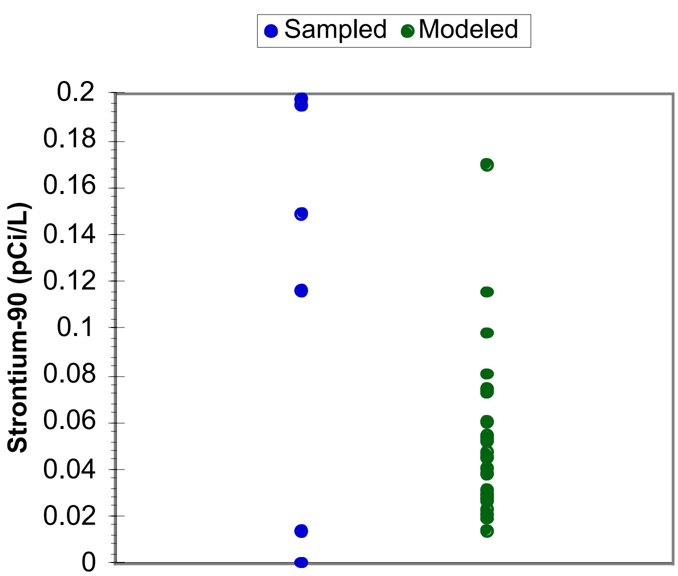

Figure 9.8. *Modeled and sampled concentrations of strontium-90 in seep water in the 300 Area in 1995.*

Figure 9.9 shows a comparison of the modeled seep concentration of uranium at the 300 Area to the sampled seep data for 1995. The modeled results are the sum of the uranium-234, -235, and -238 isotopes while the sampled data are the sum of uranium-234 and -238. These sums are comparable due to the low abundance of uranium-235 expected in the 300 Area. The modeled values substantially underestimate the sampled concentrations in this example. Given the promising history matching results for other nuclides in the 300 Area, this example suggests that the modeled inventory and/or mobility of uranium may be low in the 300 Area.

Figure 9.10 shows a comparison of the modeled seep concentration of technetium-99 at the Hanford town site to the seep data sampled in 1995. The modeled data are somewhat lower than the sampled data, but are not necessarily inadequate due to the comparison of annual time-averaged values with seep samples taken during low river stage.

The adequacy of the riparian zone model depends in part on the adequacy of the groundwater and river transport models, and all other models that precede them. The history matching results indicate that as a stand-alone module, the Riparian Zone Module can provide realistic estimates of contaminant concentrations.

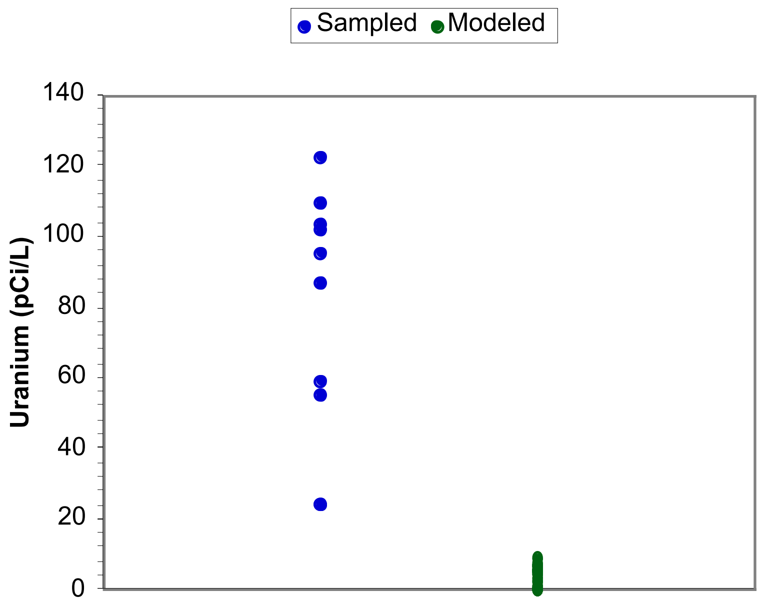

Figure 9.9. *Modeled and sampled concentrations of uranium in seep water in the 300 Area in 1995.*

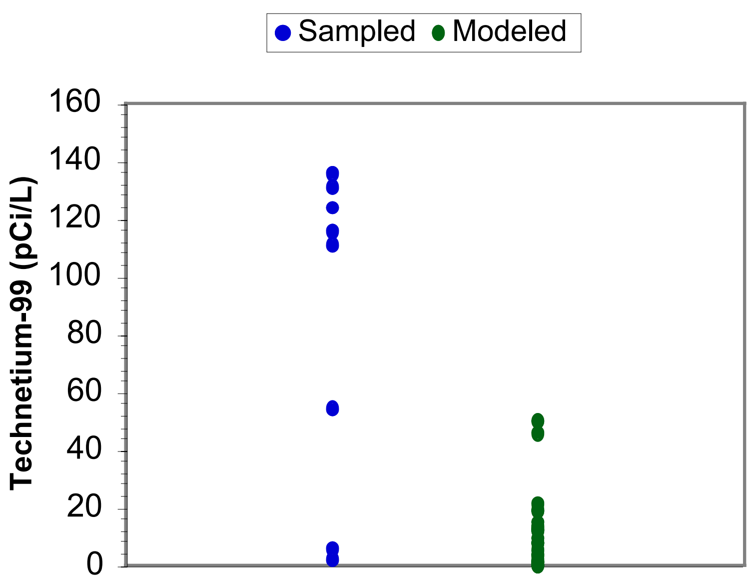

Figure 9.10. *Modeled and sampled concentrations of technetium-99 in seep water at the Hanford town site in 1995.*